



Seismic Studies on the Blake Ridge Gas Hydrates Operations

VSP Operations

VSP operations were carried out in conjunction with the Resolution at Sites 994D (3147.131°N, 7532.726°W) and 995B (3148.244°N, 7531.360°W). Our operations involved: (1) firing of the GI gun at ~15s intervals (randomized about a 0.4s mean during the first 5 station depths of Leg 2, (2) recording of shot-time instants using the SAIL system and (3) recording of navigation data in the form of 5s fixes from a P-code GPS receiver, 20s fixes from the Ashtech GPS receiver, and 1 minute fixes from the ship board GPS.

Shot instant times were recorded using the shot_log program run on a PC. The program was terminated at the end of each VSP line and the shot time files downloaded to floppy disk. A rising-edge pulse was sent to the sail clock of the shot-logging system directly from the trigger which powered the solenoids to fire the gun. The delay time between this trigger pulse and the actual firing of the gun was measured to be 0.0093 s during both legs. This delay, when added to the GPS/Sail-clock offset time of 0.0007 s, results in a net delay of 0.0100 s, between the logged shot times and the actual shot instant time.

Originally, it was planned to intermingle zero-offset and walkaway VSP measurements, so that the seismometer tool was moved through the hole only once. Spacing of the walkaway stations was planned to be 80 m with zero-offset VSP stations located every 8 m.

During the first Leg, walkaway operations were only carried out at two receiver depths, 482 and 645 mbsf. Furthermore, at the 482 mbsf only the southwestern half-spread of the airgun profile was shot. This was mainly due to expansion within the hole and to problems with unclamping the VSP tool within the borehole. The shooting itself went smoothly without incident. The shot randomizer was not used however, since the shot_log program appeared to be unstable during testing and recovery of shot times should the program fail would be easier if the randomizer was switched off. The first experiment (495 mbsf) was conducted on 17 Nov. (Julian Day 321) 15:31 - 16:36 GMT. After that, the Resolution reported problems with one of the clamping arms of the VSP tool, so that the tool had to be hauled in for repairs. The hole was then reconditioned. We therefore acquired SCS lines before resuming shooting the second VSP line (645 mbsf) on 18 Nov. (Julian Day 322) from 19:32 - 21:24 GMT. When it turned out that again one of the clamping arms broke while trying to unclamp the tool, the Resolution decided to abandon the walkaway VSP experiment in this hole and to try instead to resolve the problems with the tool before starting the next VSP experiment at Site 995. Because only two depths of a planned set of eight walkaway stations were completed successfully, we decided to conduct an OBS line at this site to provide more ray path coverage.

During the second leg, the operations in the drillhole went without any significant

problems. This had been achieved by several improvements: 1) the decision to conduct the walkaway experiment independent of the zero-offset VSP experiment, 2) the immediate employment of the "side-entry sub", with a strategy of conducting one walkaway per each section of drill pipe removed above the side-entry sub, yielding a station spacing of 72 meters depth, and 3) adjustments to the operation of the VSP tool's clamping arm. Walkaway experiments were conducted at the following depths below seafloor: 680, 608, 536, 464, 392, 320, 248, and 276 mbsf.

The experiment occurred between 29 Nov. (Julian Day 333) 18:48 and 30 Nov. (Julian Day 334) 17:08 GMT in 2- to 3.5-m seas with the Hatteras transiting perpendicular to the swell. The shot-time logging system failed on several occasions. The first failure was from 01:07 to 01:45 of V995B03. When it was noticed that the shot_log times were not updating, the PC was rebooted and normal operation resumed. The problem reoccurred ~1 hour into the shooting of V995B06. This occurrence coincided with a substantial roughening of the sea state causing rolls up to 30 degrees as winds increased to 25 kts. An effort was made at this point to analyze the problem. The shot_log program display was blinking as it received triggers, but the shot times were not updating and an error message - unreadable - was also blinking onto the screen. The PC was rebooted twice to resume normal operation, but it was noticed that the shot logger was occasionally updating at 1s intervals.

Using an oscilloscope, we verified that triggers were being sent properly from the randomizer. Flashing lights on the blue control linking the SAIL logger with the PC box also seemed to suggest that the sail loop was being activated in the proper manner. The randomizer was turned off at this point to aid in recovery of subsequent shot times. Attempts to port Procom and shot_log to a lap top were not successful. The system failed again during line 7 from 12:25-12:42 and 13:01-13:06, and during line 8 for the final 10 minutes of shooting.

We suspect that the extreme motion of the ship may have played a role in the system failure. We note also that during normal operation it was not possible to address the floppy drive B: immediately after ending the shot_log program without first rebooting the PC and that upon a soft reboot (ctrl-alt-del) we invariably encountered a "keyboard failure" error message.

An additional failure occurred at the start of V995B05 due to operator error. The GPS offset was checked at the end of V995B04 and the sail clock was left in the "arm" position for ~20 minutes into the shooting of V995B05. A copy of the manual for the shot logging system is available at the US Geological Survey Data Library (Woods Hole).

OBS Deployments

Two deployments of two USGS OBSs were performed on the second leg. The first OBS deployment was ~100 km south of the ODP sites in an area with no strong BSR, weak blanking and ~3650 m water depth (

Deployment 1 : deployment, recovery and waypoint positions.

OBS Deployment / Waypoint	Deployed Position	Recovered Position
OBS A2	30.9382 N / 75.7209 W	30.9374 N / 75.7326 W
OBS A3	30.9436 N / 75.6944 W	30.9412 N / 75.7070 W
Waypoint East	30.9737 N / 75.5478 W	-
Waypoint West	30.9087 N / 75.8675 W	-
Waypoint North	31.0631 N / 75.7291 W	-
Waypoint South	30.8178 N / 75.6596 W	-

Deployment 2 : deployment, recovery and waypoint positions.

OBS Deployment / Waypoint	Deployed Position	Recovered Position
OBS A2	31.7780 N / 75.5647 W	31.7826 N / 75.5620 W
OBS A3	31.7855 N / 75.5454 W	31.7900 N / 75.5424 W
Waypoint East	31.8379 N / 75.4107 W	-
Waypoint West	31.7332 N / 75.6803 W	-
Waypoint North	31.9001 N / 75.6070 W	-
Waypoint South	31.6709 N / 75.4838 W	-

). This site was chosen to provide a control wide-angle dataset for comparison with data from the hydrate-bearing sediments of the Blake Ridge. The second deployment was located over the 994D drill site in ~2800 m of water and was designed to complement the incomplete VSP experiment acquired on the previous leg. The geometry of these experiments (*Figure 5* and *Figure 6*) incorporated perpendicular, ~30-km-long, strike and dip lines with the OBSs located in the center along the strike lines and separated by 2.5 and 2.0 km in the first and second deployments, respectively.

Both experiments were conducted in fair weather without significant incident. The second deployment was shot in two stages, with data being acquired only between the east-west and north-south waypoints. The instruments were deployed and the east-west line shot. The Hatteras then sailed from the area in an effort to rendezvous with the R/V Susan Hudson and transfer Greg Lovelace to the Hudson. This attempt was aborted due to weather too severe for the Hudson. We then returned, completed the north-south portion of the experiment and recovered the instruments. The data appear to be of very high quality (*fig. 10*).

Underway Operations and Data Management

Matlab and GMT were installed on the SGI workstation while underway in order to process and plot navigation data and to perform the following tasks: calculating ranges for the VSP walkaway and OBS lines; plotting ship tracks and organizing SCS data into an orderly line-number system; placing latitude and longitude of shots into the SEG-Y headers of the SCS data; and generating maps for the cruise report. These tasks were performed successfully. We failed on each instance, however, to electronically transmit shot times with calculated ranges: the multiple-file format of the shot-time/range data was not transmitted properly via the COMSAT e-mail system of the Hatteras. We managed, however, to manually provide shot_log files for the walkaway VSP experiment at Site 994D during personnel transfer to the Resolution. Following the VSP operations at 995B, the quick rendezvous with the Resolution did not permit adequate time to process the navigation data for all walkaway lines.

The GMT mapping software (Wessel and Smith, 1991) was used to generate shiptrack maps of the acquired seismic lines. These maps were based on the 5 s P-code fixes and shot times which were recorded to the nearest second in the SEG-Y headers of the SCS data. The shiptrack maps were used to organize the SEG-Y data into files corresponding to numbered lines (

Table 4: Receiver depths of walkaway VSP experiment in ODP Leg 164 Hole 995B.

line	depth (mbrf)	depth (mbsf)	begin (1)	end (1)	Rem.
V995B01	3468	679.8	333 18:48	333 21:24	-
V995B02	3396	607.8	333 21:56	334 00:15	-
V995B03	3324	535.8	334 00:46	334 03:00	(2)
V995B04	3252	463.8	334 03:23	334 05:31	(2)
V995B05	3180	391.8	334 06:03	334 08:20	(2)
V995B06	3108	319.8	334 09:15	334 11:23	(2)
V995B07	3036	247.8	334 12:24	334 14:32	(2)
V995B08	2964	175.8	334 15:06	334 17:08	(2)

(1) Julian Day and Greenwich Mean Time.

(2) Slacking a few meters.

Refer logs from R/V JOIDES Resolution for further details.

Coordinates of bore hole: 31° 48.244' N, 75° 31.360' W

Depth of seafloor: 2788.2 m below rig floor (mbrf)

Approximate depth of BSR: 440 m below sea floor (mbsf).

). The shot times extracted from the SEG-Y headers were linearly interpolated onto the gun positions determined at the 5 s P-code fixes and placed into the SEG-Y headers in 2-byte positions 70-75 as degree, whole minute, and decimal portion of minute.

Media Coverage

The growing interest in hydrate research by academic and government scientists has caught the attention of the popular media as well. Because the Cape Hatteras legs were short and berthing was available, they were a convenient platform for media personnel to observe operations on the Hatteras and transfer to the Resolution.

Five media persons participated in the two legs: four guests were aboard for the first leg - a contributing editor from Popular Science (Judith Gunther) and three representatives of Independent Television News (ITN) in Great Britain (Julian Rush - science producer, Andrew Veitch - science reporter, and Robert Hammond - camera man). On the second leg, a director of the research news service of the University of North Carolina (David Williamson) was aboard. Each of these five observers spent at least a day aboard the Resolution conducting interviews, taking pictures, and filming.

The documentary video produced by the ITN team aired on Friday, 24 November 1995, in Great Britain, and was subsequently carried to Cable Network News (CNN) in the US and internationally. Copies of the video are archived at the Data Library, US Geological Survey, Woods Hole. As of April 1996, the article for Popular Science has not yet been published.